

CPUC Energy Storage Use Case Analysis

Customer-Sited Distributed Energy Storage

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1. Overview Section

Electrical distribution system operation and maintenance costs are expected to increase with the growing popularity of utility customer-sited solar generation and electric vehicles. By encouraging adoption of customer-sited Distributed Energy Storage (DESS) systems through a variety of utility rate-based applications and demand response type programs, customers and third-party service providers gain more control over utility bill **energy and demand** costs while load-serving entities gain better awareness of interconnected generation, better awareness of local electrical grid conditions, and provide control strategies to help defer network upgrades and prolong asset life.

2. Use Case Descriptions

A customer-sited Distributed Energy Storage system (DESS) combines electricity storage, power systems, and real-time communication to control shared benefits between two parties: 1) load-serving entities such as **utilities**, and 2) utility residential and business **customers**. The following use case describes customer-sited storage designed to manage customer electricity costs while providing utilities with a way to better monitor and control distribution system operating and maintenance costs. A customer and/or third party owns part or all of the DESS and the stored energy is used to manage customer bills costs, is operated by the utility to manage the distribution grid, or some mixture of both. Additionally, we see opportunity for utilities to own functional components of a non-utility owned DESS to reduce rate-based infrastructure costs by leveraging non-utility investment.



Customer Bill Management

The **customer** owns the DESS or purchases on-site DESS services from a utility or third party system owner. Each system is sized according to the specific needs of the customer and the site, minimizing component and installation costs under existing safety and communications standards. The customer receives value from displacing the highest priced electricity reflecting

unbundled energy supply and delivery costs. The DESS is a virtual hub for customer power systems to connect and interact with the grid while ensuring the greatest possible return on investment. Customer power systems such as, but not limited to:

- variable energy resources (photovoltaic solar, wind, fuel cells)
- electric vehicle chargers
- building energy management systems
- programmable control thermostats
- critical load panels (back-up power)

For business customers, stored energy is used on-site to strategically reduce monthly maximum and peak demand on the grid to produce bill cost reductions (demand and energy). When installed with renewables like photovoltaic solar, the DESS is used to reliably reduce site demand in addition to reducing exports during periods when generation exceeds site consumption.

For residential and multi-family residential property owners, the DESS is used with on-site renewable generation and owned by the homeowner, multi-family property owner, or third party system owner. Most residential tariffs lack kilowatt demand charges but the DESS can 1) offer peak-period energy savings for customers on time-of-use tariffs, 2) earn bill savings during residential critical-peak pricing events, 3) provide reliable emergency power during grid-outages, 4) used to charge electric vehicles during high cost use periods.

Customer Bill Management + Market Participation

A coordinated system behind the customer meter; controlled by two or more parties where the load-serving entity owns rights to control operation of the system under specific conditions. In simplest form, this can involve selling DESS capabilities into the Ancillary Services markets. However, the physical modularity and virtual divisibility of a DESS allows customers and utilities to divide storage capacity and control of a DESS in ways not previously imagined. Both parties have measurable opportunities that are not mutually exclusive. Policy mechanisms such as technology incentives, tariff options, and demand-response programs are the interface between the customer and utility value propositions. Control of DESS from the cloud means individual DESS resources can be virtually divided between utility and customer using software-as-a-service platforms. Much like partitioning a computer hard-drive, the customer or third party system owner enters into agreement with the utility to secondarily lease a portion of the DESS capacity and control from behind the electric meter so the utility can better manage the distribution grid.

Behind the Meter Utility Controlled - Cooperative or Third-Party Asset Ownership

This use case assumes utility control of the energy storage asset. This use case can provide all of the societal economic benefits of a energy storage system that is placed on the utility side of the meter (see Community Energy Storage Use Case and Substation Use Case). Benefits to the utility customer such as backup power can be enhanced by placing energy storage behind the meter. The ownership model of the energy storage system can vary and includes utility ownership, utility customer ownership, third party ownership, or hybrid ownership. For example, the utility could provide a financial incentive for exclusive control of the energy storage device, except during utility outage periods. Other options include customer or third-party ownership of the permanent DESS power delivery system and with utility ownership of the batteries. Among compatible technologies, storage supply at each site can be incrementally added or subtracted by the utility as grid conditions demand. Utilities gain access to almost instant power quality and demand information about customer usage and distribution grid operational conditions. In addition to supplying a reliable set of services to utility customers, any number of DESS can be remotely operated to control regional circuit power quality and circuit health during periods of high demand variability.

2.1 Objectives

Residential and business customers are positioned well to leverage DESS tariff options, incentives, and demand management programs that **encourage customer investment** within highly optimized, utility-deployable resources that are used to manage a grid with increasingly variable utility customer power needs (electric vehicle, renewable power, reliability, consumer appliances). Immediately, the DESS can:

- Reduce load management costs by intelligent and optimized peak load shifting
- Mitigate negative impacts of intermittent/variable wind and solar generation on the distribution grid by firming at the source of generation
- Enhance accuracy of grid analytics with real-time visibility into distributed resources
- Defer distribution system maintenance while improving grid operability for utilities using consumer sited distributed renewables installed parallel with responsive, co-operative battery storage.
- Reduce distributed scale (<1MW generation/storage capacity) project installation costs.

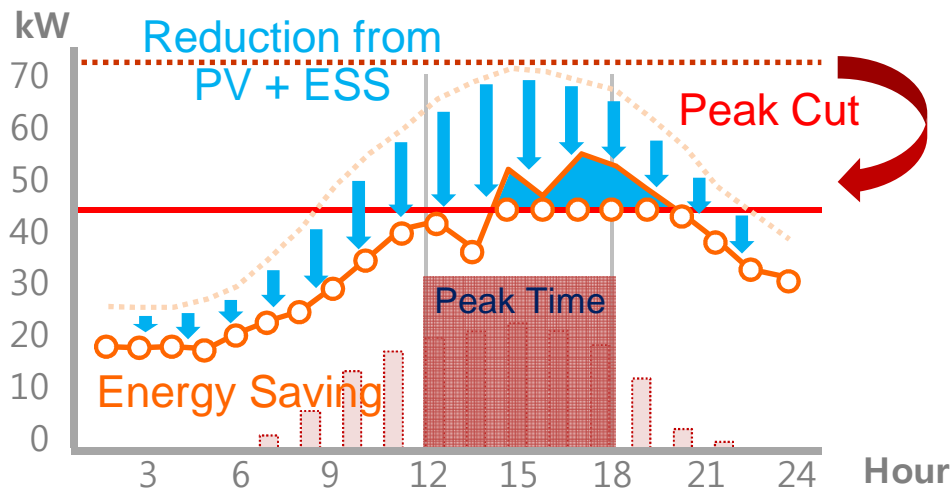


Figure 1. PV + Storage Example

Preparing for the future, the DESS can:

- Accelerate the deployment of Electric Vehicles while mitigating increased demand variability
- Enhance effectiveness of demand response by guaranteed targeted dispatch upon command
- Improved grid reliability and efficiency by improving power quality at the edges of the distribution network

2.2 Actors

Some or all of the battery capacity may be owned by the utility and all other DESS equipment, not including the battery, is non-utility owned by one or more of the following parties:

1) the utility customer, 2) a third-party aggregator of customer storage resources, 3) a third party system owner that operates the facility under a long-term power purchase agreement with the utility and/or host customer, and 4) a DESS system operator that operates and maintains DESS hardware and software.

Name	Role description
Utility	Rate-based ownership of consumer oriented appliances, distribution system operator, energy supplier, power procurement
Electric Utility	Property owner, electric customer, potential storage owner

Customer, Host	
Third-Party Aggregator	Vendor offering short-term energy services to utilities and utility customers
Third-Party System Owner	Supply distribution services to utility through long-term power agreements
System Operator	Operates and maintains DESS hardware and software

2.3 Proceedings and Rules that Govern Procurement Policies and Markets for This Use

<i>Agency</i>	<i>Description</i>	<i>Applies to</i>
CPUC	Commercial technology incentive programs	SGIP, CSI (RES & Non-RES)
Utility/CPUC	Demand response programs	
Utility/CPUC	Utility Tariffs (NEM, FiT, RESBCT, etc)	
Federal Tax	FITC	
CEC	Definition of Renewable Technology	Ability to interconnect storage on NEM or VNM meters with renewable generation on site

2.4 Location

The DESS interconnects to the distribution grid at or near electric customer service delivery points, typically from behind the customer meter. It charges from on-site renewable energy generation or the grid and discharges to customer load or the grid. The DESS is both located at a single site and can be aggregated over multiple sites. Solar energy may or may not be co-located.

2.5 Operational Requirements

Participating DESS products must meet minimum communication and operational thresholds to be eligible for utility tariffs, demand response programs, and real-time ancillary services (Regulation, Power Quality) to the utility.

Software and power electronics aggregate systems together in a secure, real-time network for the delivery of both energy and information to customers and utilities alike. Software services pool and dynamically scale energy resources across the grid upon demand. Multiple applications are delivered to multiple parties from each DESS. Additional examples of required capabilities include:

- Optimize the amount of load reduced during the peak load period by dispatching energy (effectively “offsetting” energy consumption at the site)
- "Time-shift" energy generated from PV and/or drawn from grid to maximize peak load reduction for a home or business
- Limit the export of solar generation to the grid by storing solar generation that is produced in excess of site demand
- Supplement the intermittent nature of renewable generation with the stored energy in its battery, each appliance can “smooth” a percentage of the generating capacity provided to the grid, making it more reliable, more predictable, and more stable.
- Respond to Demand Response events with guaranteed dispatch of power to the grid. DR events can either be scheduled in advance or sent in real-time.
- Respond to needs for voltage and reactive power control by injecting or absorbing power
- Respond to regulation signals on a per-second basis
- In the event of a loss of power, the appliance automatically isolates itself from the grid, and then delivers its own power to the site without any interruption in service or loss in power quality.

The energy storage asset should be able to dispatch energy coincident with periods of peak power consumption from the grid. This can be accomplished through a programmable interface to allow the system to discharge to coincide with peak load. Alternatively, the system could employ adaptive logic, which would account for various factors such as weather, onsite renewable generation, utility tariffs structure, and other variables to automatically dispatch energy at appropriate levels to reduce or eliminate peak demand. The system must be fast responding (1hr or less notice). Ideally, the system would employ some fashion of battery management system to monitor the health and state of charge of the systems batteries, the overall site load conditions, and the health and frequency of the grid at the customer interconnection point.

For behind the meter energy storage assets owned by utility’s seeking to aggregate multiple systems, the energy storage asset should employ some type of communication interface to allow the utility to remotely control the charge and discharge of the system.

2.6 Applicable Storage Technologies

The potential storage devices that are most applicable to this use case are capable of routinely and/or adaptively sized to support the reduction of customer demand (imports and exports) on the grid. Currently, the most common technologies lead acid and li-ion. However, Redox Flow Batteries (RFB) are also suited for large capacity energy storage¹.

<i>Storage Type</i>	<i>Storage capacity</i>	<i>Discharge Characteristics</i>
Li-ion Battery	Short to medium duration 4 milliseconds to 4 hours	Fast response time 1kw to 2MW
Compressed-air	Short to medium duration 30 minutes to 4 hours (or longer)	Medium response time 1kW to 2MW
Redox Flow Batteries (RFB)	Short to long duration 30 minutes to 6 hours (or longer)	Medium response time 250 kW to 2 MW
Lead-acid and advanced lead-acid	Short to long duration 30 min to 6 Hrs	Medium response time 1kW to 2MW
Ice Thermal Energy Storage	Medium to long duration 4 to 6 Hrs	Fast response time, cooling loads 120 to 2MW

2.7 Non-Storage Alternatives for Addressing this Objective

Among the non-storage options for meeting the reduction of demand and demand charges are.

- Distribution system upgrades to accommodate bi-directional flow and high load variability
- Customer sited and dispatchable generators
- Customer sited SCADA
- Automated demand response

¹ The decoupling of power and energy unique to RFBs provides maximum flexibility to size system power and energy appropriately for the target application from common building blocks.

3. Cost/Benefit Analysis

3.1 Direct Benefits

End Use (Primary = P, Secondary = S)	Bill Management			Bill Management + Market Participation		Behind the Meter Utility Controlled	
	Business Customer, Peak/Max Demand Mgt.	Residential Customer, Renewable Integration	Multi-family Residential, Solar and Demand Mgt.	Business Customer, Bill + Market Participation	Residential Customer, Bill + Market Participation	Cooperative Ownership, Grid Operation Benefits	3rd Party Aggregator, Grid Operation Benefits
	Batteries, CAES, ICE, RFB	Batteries, CAES	Batteries, CAES, RFB	Batteries, CAES, Thermal, RFB	Batteries, Thermal, CAES	Batteries, RFB	Batteries, RFB
Utility Control				Yes	Yes	Yes	Yes
Frequency Response				S	S	S	S
1. Frequency regulation				S	S	P	P
2. Spin				S	S	S	S
3. Ramp				S	S	S	S
4. Black start				S	S	S	S
5. Real-time energy balancing				S	S	S	S
6. Energy arbitrage				S	S	S	S
7. Resource Adequacy				S	S	S	S
8. VER[1] /				S	S	S	S
wind ramp/volt support,							
9. VER/ PV shifting, Voltage sag, rapid demand support				S	S	P	P
10. Supply firming	P When combined with onsite renewables	P When combined with onsite renewables	P When combined with onsite renewables	P When combined with onsite renewables	P When combined with onsite renewables	S When combined with onsite renewables	S When combined with onsite renewables
11. Peak shaving: load shift							
12. Transmission peak capacity support (deferral)							
13. Transmission operation (short duration performance, inertia, system reliability)							
14. Transmission congestion relief							
15. Distribution peak capacity support (deferral)	S	S	S	P	P	S	S
16. Distribution operation (volt/VAR support)	S	S	S	P	P	P	P
17. Outage mitigation: microgrid	S	S	S	S	S	S	S
18. TOU energy mgt	P	P	P	P	P		
19. Power quality				S	S	S	S
20. Back-up power	S	S	S	S	S	S	S

[\[1\] VER = Variable Energy Resource](#)

3.2 Other Beneficial Attributes

<i>Benefit Stream</i>	<i>Benefit Provided?</i>	<i>How the benefit is captured or can be captured?</i>
Reduced Fossil Fuel Use	Y	<p>Storage could allow existing fossil units to operate at a more efficient level. Reduction in fossil use is most directly linked with reduction in GHG emissions.</p> <p>Energy storage can also allow a greater percentage of off-peak power from non-fossil resources.</p> <p>Energy storage devices could be compensated for this grid benefit through the mechanisms discussed below.</p>
Increased Transmission Utilization	Y	<p>Bulk storage devices connected to the transmission system could increase utilization of transmission assets or defer upgrades. Current FERC accounting rules prevent a resource classified as a transmission asset from earning wholesale market revenues simultaneously. Additional clarity from FERC is necessary. Refer to “transmission peak capacity support” in section 3.2.</p> <p>This benefit is very locational dependent and providing such a benefit will constrain operations for charging, discharging, and providing market functions. A transmission benefit could be included provided that energy, A/S, and capacity revenue streams are adjusted to reflect the additional operational constraint due to providing a transmission function.</p>
Power Factor Correction	Y	DESS can provide power factor correction where it is needed most – at or near the load. The value of this power factor correction should be compared to other methods of distributed power factor correction.
Over generation management Increased use of renewables to meet RPS goals	Y	<p>At times of over generation, energy storage can help to avoid uneconomic curtailment of RPS and conventional resources. During periods of excess energy, the CAISO energy market prices will become negative and a storage resource that can absorb excess energy can receive compensation for charging. The CAISO currently has a bid floor of - \$150/MWh, which is</p>

<i>Benefit Stream</i>	<i>Benefit Provided?</i>	<i>How the benefit is captured or can be captured?</i>
		the maximum energy unit price for absorbing energy; this could be adjusted or storage otherwise compensated by charging from renewable energy.
Faster regulation	Y	<p>Some technologies can respond faster and provide a higher amount of benefit to the system for frequency regulation. This could also reduce the amount of frequency regulation that is ultimately procured by the CAISO.</p> <p>Implementation of Order 755 will implement pay for performance regulation. In this case, resources that can respond faster to regulation signals may receive a higher compensation – whether this occurs and its value is highly dependent on the amount of storage deployed, bidder behavior, resultant market prices, and the reduced lifetime of storage that may rise from faster dispatch.</p>
Faster build time	Y	<p>Many storage technologies can be deployed in under one year. Delayed capital deployment for a certain quantity of capacity will result in lower development cost.</p> <p>In cases where utility owns BTM assets, the time value of money should be accounted for during the RFO process. In cases where customer or third-party-owned storage can reduce the need for utilities to procure traditional assets, this value could be provided through the mechanisms described below.</p>
Locational flexibility	Y	The storage device or aggregated devices can be situated where they provide highest value. This value could come from reducing local capacity constraints, and should be passed on to the storage device through the mechanisms described below.
Size flexibility - Modularity	Y	DESS can accommodate a wide variety of aggregated system sizes. In many instances, smaller amounts of storage may be able to eliminate the need for a traditional fossil generator. The value of these resources can thus be greater than the traditional per-MW value of a resource.

<i>Benefit Stream</i>	<i>Benefit Provided?</i>	<i>How the benefit is captured or can be captured?</i>
Optionality	Y	<p>Quickly deployable, fine grained resources like storage can provide viable alternatives to long leadtime assets that need to be deployed in large sizes (like transmission lines or generators). The value arises from multiple effects:</p> <ul style="list-style-type: none"> • Time optionality: some storage technologies can be deployed when needed, as opposed to far in advance of need. • Location optionality: storage technologies can be located at a greater variety of locations than traditional assets. Those locations could be readily changed during deployment of a long term project to provide options for future growth. • Size optionality: some storage technologies can have a wider variety of sizing options than traditional generators, allowing for options that best address needs. • Purpose optionality: most storage technologies can perform a wide variety of functions, which may allow them to provide more future options for utilization than traditional resources. • Technology optionality: in a phased storage deployment, it could be possible to change technologies mid-deployment to take advantage of newer or more cost effective technologies. • Cost optionality: unlike traditional generators, storage costs are likely to fall over time. Providing for future options could allow utilities to achieve reduced ratepayer costs in the long term. <p>Ultimately, development can allow for storage to be deployed only if needed, where needed. The deployment can be timed to match economic and demographic shifts, eliminating the risk of overbuilding.</p> <p>The reduced risk of energy storage should be evaluated and accounted for as a risk reduction value. This reduced risk could be accounted for through the mechanisms described below.</p>
Multi-site aggregation	Y	<p>Aggregated distributed devices are less likely to fail simultaneously, providing a reduced risk to utilities. This reduced risk should be accounted for through the</p>

<i>Benefit Stream</i>	<i>Benefit Provided?</i>	<i>How the benefit is captured or can be captured?</i>
		mechanisms described below.
Grid/communications reliability	Y	DESS can be used to keep communication infrastructure reliable during outages. This value should be included in procurement decisions.

3.3 Compensation Mechanisms

Distributed Energy Storage Systems can provide a wide variety of benefits to the utility. In cases where utilities may procure BTM systems, these values can be directly accounted for as part of the utility procurement process. BTM systems may indeed be a suitable option for RFOs of all sizes.

However, in cases where the customer or a third party might own the system, some of these benefits are difficult to capture from behind the meter. However, the benefits can still be calculated, and indeed are no different than the benefits provided by systems located on the distribution or transmission grid. In these cases, appropriate compensation mechanisms may be highly regional or project specific, but they should not be ignored. In many cases, distributed storage may provide the most cost effective method of addressing these issues.

A variety of mechanisms could appropriately account for storage benefits to the grid. Initial ideas include:

- Storage-specific tariffs to customers with a storage system. This could include specific payments in cases where utilities control BTM systems.
- Incentives for storage devices based upon their value to utilities. Incentives could be based upon the exact value provided by storage devices in a given region or operational scheme.
- Procurement targets based upon known need. If it is known that storage could provide value, procurement targets could be set that would promote storage adoption in areas with highest value.

Value-based tariffs or incentives have the advantage of being implicitly cost effective because storage is simply compensated for the benefit provided to the utility.

With regard to Ice Thermal Energy Storage it is worth noting that systems designed for permanent customer load shifting can, with minimal modification to the control software, be

converted to serve as demand response units answering utility dispatch signals. No mechanical adjustment of the system is necessary beyond installation of the signal equipment.²

3.4 Costs

<i>Cost Type</i>	<i>Description</i>
Installation	
O&M	
Warranty	

3.5 Cost-effectiveness Considerations

Utilities have the ability to drive large volumes and creating a very cost competitive market for this type of distributed energy storage equipment. Large format, cost effective battery technology is being driven by the electric vehicle industry. The batteries comprise the largest cost component of the distributed storage solution. Battery costs are linear in respect grid scale (large centralized energy storage systems) and distributed BTM energy storage systems.

The real savings of BTM energy storage systems comes from the reduction in non-equipment costs. These costs include planning, installation, site acquisition costs, etc. Because the units located at an electric customer's site the utility avoids many site planning and construction issues. The customers who opt into the program provide many of these services in exchange for the emergency backup features of energy storage during a grid outage.

In the case of utility operated BTM systems, the utility benefits can match the benefits of Community Energy Storage (CES) devices located on the distribution grid. Utility operated BTM systems may combine CES benefits with customer-side benefits to create a highly cost effective system.

In cases where storage and renewable generation are installed behind a single inverter, special consideration must be made to not encumber efficiently designed systems with added inverter and metering costs as is currently required by some utilities to be eligible for Net Energy Metering (NEM) tariffs. A new storage-centric tariff similar to NEM but designed for renewable generation (solar, wind, fuel cells) optimally paired with storage to firm variable generation as a way to reduce both utility interconnection study costs and project installation costs.

With regards to Redox Flow Batteries (RFBs), System power is tailored via integrating groups of electrochemical stacks with power electronics. Optimizing system energy is achieved by

² Terry Andrews, CALMAC.

adjusting the volume of liquid electrolytes and tank sizes. As result, RFB cost per kWh decreases with increased duration.

4. Barriers Analysis & Policy Options

4.1 Barriers Resolution

<i>Barriers Identified</i>	<i>Relevant Y/N</i>	<i>Policy Options / Comments</i>
System Need		<p><i>What is the barrier?</i></p> <p>There is not clarity around the future needs and attributes for the California system to maintain reliability with 33% renewables. As a result, it is not known what attributes are needed to manage the future system.</p> <p>Demand side resources need to be taken into account</p> <p><i>How is it a barrier?</i></p> <p>LSEs cannot send definitive signals on their future procurement needs.</p> <p><i>What are the potential resolutions?</i></p> <p>Evaluate system needs holistically and look into areas where demand side resources provide cost effective solutions to long term system needs.</p> <p>An alternate option is to rely on the LTPP to solely determine the future system needs and attributes for meeting that need. The LTPP would also provide the authorization for the CPUC jurisdictional utilities to engage in procurement. The storage OIR can ensure that CAISO modeling and CPUC LTPP do not bias against demand side storage participating to address future needs.</p>
Cohesive Regulatory Framework		<p><i>What is the barrier?</i></p> <p>Existing regulatory framework does not consider demand side resources for meeting generation or transmission identified needs.</p> <p>To the extent transmission is a rate based asset, it is considered</p>

<i>Barriers Identified</i>	<i>Relevant Y/N</i>	<i>Policy Options / Comments</i>
		<p>differently than non-rate-based resources like energy storage.</p> <p><i>How is it a barrier?</i></p> <p>Storage can be used to reduce the amount of transmission infrastructure needed in the system. There is a regulatory and decision making gap between the FERC, CPUC, and CAISO's transmission planning processes.</p> <p><i>What are the potential resolutions?</i></p> <p>System planning should adequately consider customer sited storage may have a role to play in alleviating needs in the bulk transmission system, including transmission needs, thus demand side resources should be considered in planning processes that have historically not included demand side resources.</p> <p>Expanded planning processes must treat resources fairly.</p>
Evolving Markets – A/S		<p><i>What is the barrier?</i></p> <p>The future A/S products are not defined yet.</p> <p>Behind the meter utility owned/operated systems have not been clearly defined.</p> <p>Behind the meter A/S participation has also not been clearly defined.</p> <p><i>How is it a barrier?</i></p> <p>Without clearly defined market and ownership rules, it is difficult to finance and develop energy storage systems.</p> <p><i>What are the potential resolutions?</i></p> <p>The CAISO is in the process of implementing pay for performance regulation, regulation energy management for sub 1-hour resources, updated market models to allow selling ancillary services during charging, and flexible ramping product.</p> <p>CPUC might consider a policy to allow utility ownership and/or operation of behind the meter assets.</p> <p>It may make sense to pay directly for value provided to the grid by a customer-sited storage device under a certain operating</p>

<i>Barriers Identified</i>	<i>Relevant Y/N</i>	<i>Policy Options / Comments</i>
		scenario.
Evolving Markets – RFO Process		<p><i>What is the barrier?</i></p> <p>Current utility RFOs do not allow for aggregated DESS to bid on wholesale bids.</p> <p><i>How is it a barrier?</i></p> <p>DESS can provide benefits to the utility customers as well as the distribution and transmission system. Currently, it is not possible to bid into traditional utility procurement, which limits DESS adoption.</p> <p><i>What are the potential resolutions?</i></p> <p>RFOs should allow for distributed and/or utility controlled BTM systems, and correctly evaluate the value of BTM systems.</p>
Resource Adequacy Value		<p><i>What is the barrier?</i></p> <p>There are no clear rules for the RA credit that customer sited energy storage can count for. There is no long term procurement under RA.</p> <p><i>How is it a barrier?</i></p> <p>Energy storage provides capacity that is flexible. The current RA rules do not differentiate between flexible RA and non-flexible RA. To maximize the value of storage, long term procurement is needed.</p> <p><i>What are the potential resolutions?</i></p> <p>The RA proceeding will establish RA rules for energy storage and is investigating having differentiated RA products, including flexible RA. It is not clear if this will be a large enough incentive to help make energy storage cost-effective. Storage isn't defined for resource adequacy.</p>
Cost Effectiveness Analysis		Cost effectiveness should focus on creating a framework that defines what the sources of value are and the beneficiaries.

<i>Barriers Identified</i>	<i>Relevant Y/N</i>	<i>Policy Options / Comments</i>
Cost Recovery Policies		<p><i>What is the barrier?</i></p> <p>Cost recovery policies for customer sited systems are undefined. Multiple cost recovery policies might be necessary to address all potential uses of energy storage.</p> <p>Lack of revenue predictability for non-rate-based assets make financing and/or selling projects difficult.</p> <p><i>How is it a barrier?</i></p> <p>Products that storage provides, such as A/S are not procured on a forward basis through long-term contracts</p> <p><i>What are the potential resolutions?</i></p> <p>A wide range of cost recovery policies need to be evaluated and implemented as appropriate.</p> <p>Need ability to secure long-term (greater than 10 years) contracts with guaranteed revenue for that duration. That will help unlock project funding for deployment of storage.</p> <p>There could be an ability to get long term, guaranteed revenue contracts for the financial life of storage projects when they are deployed for ramping services, frequency regulation, RA and other services.</p>
Cost Transparency & Price Signals		<p><i>What is the barrier?</i></p> <p>Lack of consistent of electricity tariffs make financing DESS projects difficult.</p> <p><i>How is it a barrier?</i></p> <p>Bill Management customers need to have predictable tariffs in order to invest in storage. Three different utilities have different tariffs, which can make project development more complex.</p> <p><i>What are the potential resolutions?</i></p> <p>Create storage-specific predictable tariff structures which</p>

<i>Barriers Identified</i>	<i>Relevant Y/N</i>	<i>Policy Options / Comments</i>
		properly compensate customers for value provided by storage devices.
Commercial Operating Experience		<p><i>What is the barrier?</i></p> <p>Many technologies do not have sufficient operating experience to reduce costs and promote investment by utilities.</p> <p><i>How is it a barrier?</i></p> <p>New technologies find it difficult to compete with incumbent technologies that have less technology risk.</p> <p><i>What are the potential resolutions?</i></p> <p>Incentivize field demonstration. Help to define path to commercialization.</p>
Interconnection Processes		<p><i>What is the barrier?</i></p> <p>Complex and expensive interconnection rules for behind the meter systems of all types.</p> <p>For systems managed by utilities, aggregated systems, and/or systems participating in CAISO A/S markets, there are additional issues that need to be resolved.</p> <p><i>How is it a barrier?</i></p> <p>The interconnection process and rules are prohibitively expensive and time consuming for DESS.</p> <p><i>What are the potential resolutions?</i></p> <p>Comprehensive solution that fixes Net Energy Metering and Rule 21.</p> <p>Create an interconnection fast track for certain types of storage paired with renewables.</p> <p>Revise interconnection rules and requirements for aggregated DESS systems participating in A/S and/or providing grid operation</p>

<i>Barriers Identified</i>	<i>Relevant Y/N</i>	<i>Policy Options / Comments</i>
		benefits under utility control.
Optionality Value	Yes	<i>Please see optionality clarification document, released separately.</i>

4.2 Other Considerations

Combinations of energy storage devices installed in concert with renewables for mid-to-large commercial customers could have beneficial synergies with respect to cost and performance. Work must be done to explore the value of combinations of storage from a cost effectiveness perspective.

5. Real World Examples

5.1 Multi-family Residential Solar with Li-ion Storage

Location	Southern California
Company	Sunverge Energy, Inc.
Technology	Solar Integrated Li-ion Storage
Operational Status	In Development
Ownership	Third Party Owned, PPA to Property Ownership
Primary Benefit Streams	Virtual Net-Energy Metering Excess PV Generation Time-Shifting
Secondary Benefits	Common Area Demand Management
Available Information	>CSI and SGIP incentive reservations >2 MWac photovoltaic solar >90% serving tenant loads, 10% connected to Common Area >180kWac / 350kWh of Li-ion DESS for Common Areas >Projected online by Q3 2013
Contact Information	Jon Fortune, PE Director, Regulatory & Energy Services Sunverge Energy, Inc. sunverge.com jfortune@sunverge.com 619-573-9357office

The project consists of two discrete types of power system co-existing on four separate multi-family properties. One system type is a virtually net-metered photovoltaic generation supplying tenant loads. The second system type is photovoltaic generation paired with a Li-ion DESS optimized to common area meter loads. The DESS is designed prevent solar energy exports and reduce customer demand as solar generation begins to wane. All four sites are within a single utility territory and could provide additional value to the load serving entity under a short or long-term DESS distribution services contract.

5.2 Residential Solar with Li-ion Storage

Location	<i>Korea (Jeju Island)</i>
Company	Samsung SDI
Technology	Li-ion
Capacity	
Operational Status	Operational
Ownership	Residential
Primary Benefit Streams	Backup, solar shifting
Secondary Benefits	
Available Cost Information	
Contact Information	Ben Williams Ben.williams@samsung.com 847.407.2856 935 National Parkway Suite 93520 Schaumburg, IL 60630

5.3 Commercial Demand Reduction with Ice-Bank Thermal Energy Storage

Location	1500 Walnut Street, Philadelphia, PA
Company	CALMAC
Technology	Ice-Bank Thermal Energy Storage
Capacity	1,300 ton hours of cooling capacity; 4 hours 160 kW or 6 hours 120 kW of electrical energy shift
Operational Status	Operational
Ownership	Commercial
Primary Benefit Streams	Peak Shaving/Load Shift, Resource Adequacy, Transmission Operation
Secondary Benefits	Time Of Use Energy Management
Available Cost Information	
Contact Information	Terry Andrews Calmac 3-00 Banta Place Fair Lawn, NJ 07410 480-659-4977 TAndrews@calmac.com

5.4 Time-Shifting Solar Energy with Redox Flow Battery

Location	Almond farm in Turlock, CA
Company	EnerVault
Technology	Redox Flow Battery
Operational Status	In Construction
Ownership	Commercial
Primary Benefit Streams	Peak Shaving/Load Shift: • Shifts Helios dual tracker PV to peak hours to power 225 kW irrigation pump
Secondary Benefits	Time Of Use Energy Management
Available Information	Projected online by Q2 2013
Contact Information	<p>Bret Adams</p> <p>Director of Business Development</p> <p>EnerVault Corporation</p> <p>1244 Reamwood Avenue</p> <p>Sunnyvale, CA 94089</p> <p>351 201 9139</p> <p>BAdams@EnerVault.com</p>

5.5 Behind the Meter Utility Controlled

Silent Power has installed 15 behind the meter OnDemand Energy Appliances in Rancho Cordova, California. The OnDemand system is self-contained energy storage unit that is grid tied and capable of an approximate 6kW output with 8.8 kWh of energy storage. The energy storage is provided by large format lithium ion batteries. The OnDemand system is fully compliant and listed to applicable UL safety standards and commercially available. The 15 systems were installed in September of 2011. The systems are owned and operated by the Sacramento Municipal Utility District (SMUD). The 15 systems are controlled by SMUD by

software that can aggregate communication to each unit allowing the 15 energy storage systems to act a single larger “grid based” energy storage system. Communication to each system is provided via a secure internet connection. Each OnDemand system is installed in a solar PV homes within a solar community. SMUD’s \$5.9 million pilot project will evaluate how the integration of energy storage enhances the value of distributed PV resources for the community, the utility and the grid by reducing peak loads, firming intermittent renewable capacity and maximizing overall system efficiency. The pilot project will allow monitoring of PV systems, along with energy storage, to give SMUD a better assessment of the value of distributed energy resources from a utility standpoint. SMUD will be able to determine how well the storage systems can support its super-peak consumption times, when output from the PV systems drops significantly. Based on these outcomes, the utility may replicate the technology throughout its service territory should it prove feasible.

Location	<i>Sacramento Municipal Utility District</i>
Operational Status	Operational
Ownership	Utility owned and controlled, installed in residential solar homes
Primary Benefit Streams	Solar shifting, solar firming
Secondary Benefits	Peak demand reduction, T&D utilization
Available Cost Information	

5.6 Outstanding Development Issues

<i>Description</i>	<i>Source</i>
Interconnection policies and standards pertaining to storage operation and monitoring	

5.7 Contact/Reference Materials

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6. Conclusion and Recommendations

Is ES commercially ready to meet this use?

- Yes, but more work needs to be done to refine technology value niches, long-term testing, and customer-utility information exchange.

Is ES operationally viable for this use?

- Yes.

What are the non-conventional benefits of storage in this use?

- The multi-functionality of storage offers the potential to future proof cost effectiveness with changing load patterns and market cost/benefit circumstances
- Any stored energy available at the time of an outage can be used onsite by the customer for emergency power (cell phone charging, etc.), especially when paired with renewables
- Real-time load and grid data, at customer sites and remotely available to utilities and customers
 - Combines numerous utility/ISO benefits with emergency backup power for electric customer

Can these benefits be monetized through existing mechanisms?

- In some cases. Storage use is sometimes constrained by regulatory policies focused on single priority applications (solar NEM, demand response, etc).
- The utility benefits of utility-controlled BTM systems are currently difficult to transfer. One mechanism could be utility ownership of BTM resources. Another could be a rebate or payment mechanism for energy storage devices behind the meter that are subject to utility control.

If not, how should they be valued?

- More needs to be done to recognize the benefits of multi-technology systems with multiple priorities and control strategies.

- Systems should be valued based upon the benefits provided. Mechanisms should be put in place to provide this value to energy storage devices, regardless of whether they are owned by utilities, third parties, or customers.

Is ES cost-effective for this use?

- In many cases, energy storage is the technology group with the most potential to provide cost-effective “multifunctional” resources distributed on customer sites.

What are the most important barriers preventing or slowing deployment of ES in this use?

- Limited track record of deployment; access to additional revenue streams

What policy options should be pursued to address the identified barriers?

- Allow broader participation of behind the meter energy storage assets in electricity markets (for example – allow bidding for ancillary services)

Should procurement target or other policies to encourage ES deployment be considered for this use?

- Yes.